PISTON TYPE COMPRESSOR

BACKGROUND OF THE INVENTION

The present invention relates to a piston type compressor for compressing a gas by reciprocation of a piston.

In general, a reed valve type of suction valve causes abnormal sound due to self-exited vibration and thereby obstructs a silent operation of the compressor. Japanese Unexamined Patent Publication No. 5-164044 discloses a rotary valve, which does not cause self-exited vibration, in a piston type compressor. The rotary valve is used as a suction valve.

In the structure of the prior art, the compressor has a plurality of cylinder bores and a valve accommodating chamber therein. A suction communicating passage is formed for interconnecting the respective cylinder bore with the valve accommodating chamber. In the valve accommodating chamber, a rotary valve is accommodated. The rotary valve has a suction guiding hole for communicating with the suction communicating passage in a suction process. The suction guiding hole has a first end surface at a preceding side in a rotational direction of the rotary valve and a second end surface at a following side in the rotary direction. The rotation of the rotary valve is adjusted in a such manner that the

first end surface of the suction guiding hole meets the suction communicating passage after compressed gas remaining in a top clearance of the compression chamber finishes re-expansion. In addition, a notch is formed on the outer circumferential surface of the rotary valve near the first end surface of the suction guiding hole, otherwise, the notch is formed on the inner circumferential surface of the valve accommodating chamber near the suction communicating passage. The notch allows inflow and outflow of a small amount of gas until the first end surface meets the suction communicating passage after the remaining compressed gas finishes the re-expansion.

In the prior art, in a suction process of the compressor, first time that the remaining gas in a working chamber of the cylinder bore finishes the re-expansion is compared with second time that the rotary valve starts intake through the notch. When the first time becomes later than the second time, the notch reduces the amount of the remaining gas that flows backward from the suction communicating passage toward the suction guiding hole of the rotary valve. An object of the prior art is, thereby, to prevent power loss of the compressor. On the other hand, when the first time becomes earlier than the second time, that is, when the suction guiding hole starts to communicate with the suction communicating passage through the notch, the gas in the working chamber becomes slightly negative pressure. Since the working chamber communicates with the suction guiding hole through the notch as soon as the gas

in the working chamber becomes the negative pressure, however, extreme reduction of the pressure in the working chamber is restrained. Therefore, gas in a suction chamber is not rapidly drawn into the working chamber. The other object of the prior art is, thereby, to prevent noise of the compressor caused due to suction pulsation.

In the prior art, however, a small-sized notch is formed only on the first end surface of the suction guiding hole and nothing is performed on the second end surface. Therefore, in a structure where the suction guiding hole of the rotary valve simultaneously communicates with a plurality of the cylinder bores, a total amount of intake gas is obtained by adding each amount of gas drawn into the respective cylinder bores, which communicates with the suction guiding hole. In that case, as shown in FIG. 4A, suction pulsation caused due to a rapid increase of gas that is drawn into the working chambers of the cylinder bores, which communicates with the suction guiding hole, is not sufficiently reduced. Therefore, the object of the prior art, that is, restraining the noise of the compressor, is not sufficiently accomplished.

SUMMARY OF THE INVENTION

The present invention directed to a piston type compressor whose suction pulsation and noise are restrained.

The present invention has following features. A piston type compressor includes a housing, a drive shaft, a cam, a piston, a refrigerant gas passage and a rotary valve. The housing defines a suction pressure region. The housing includes a cylinder block which defines a plurality of cylinder bores to form a compression chamber. The drive shaft is supported for rotation by the housing. The cam is operatively connected to the drive shaft. The piston is accommodated in each cylinder bore. The piston is operatively connected to the cam so as to be reciprocated by converting the rotation of the drive shaft. The reciprocation of the piston varies a volume of the compression chamber. The refrigerant gas passage interconnects the suction pressure region with at least one of the compression chambers. The rotary valve is integrally formed with the drive shaft so as to synchronously rotate with the drive shaft. The rotary valve includes a suction guiding hole which forms a part of the refrigerant gas passage. The suction guiding hole connects each compression chamber by turns with the suction pressure region as the rotary valve is rotated. The suction guiding hole communicates with a plurality of the compression chambers at least at early and last stages in a suction process. The suction guiding hole has a first end formed at a preceding side in a rotational direction of the rotary valve. The suction guiding hole also has a second end formed at a following side in the rotational direction of the rotary valve. The suction guiding hole further has a middle between the first end and the second end. The suction guiding hole further has a predetermined

area per unit length in the rotational direction. The predetermined area gradually increases from the first end to the middle and gradually decreases from the middle to the second end.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the present invention that are believed to be novel are set forth with particularity in the appended claims. The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a longitudinal-sectional view illustrating a variable displacement piston type compressor according to a preferred embodiment of the present invention;

Fig. 2A is a side view illustrating a rotary valve for the variable displacement piston type compressor according to the preferred embodiment of the present invention;

Fig. 2B is a partially enlarged view illustrating a suction guiding hole of the rotary valve for the variable displacement piston type compressor according to

the preferred embodiment of the present invention;

FIG. 3 is a cross-sectional view illustrating a suction valve mechanism taken along the line I-I in FIG. 1;

FIG. 4A is a graph illustrating a total amount of intake gas to a rotational angle of a rotary valve according to a prior art;

FIG. 4B is a graph illustrating a total amount of intake gas to a rotational angle of a rotary valve according to the preferred embodiment of the present invention; and

FIG. 5 is a side view illustrating a rotary valve for a variable displacement piston type compressor according to another preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A variable displacement piston type compressor for use in a vehicle air conditioning apparatus according to a preferred embodiment of the present invention will now be described with reference to FIG. 1. In Fig. 1, a left side of FIG. 1 is a front side and a right side thereof is a rear side.

As shown in FIG. 1, a variable displacement piston type compressor includes a cylinder block 11, a front hosing 12 and a rear housing 14. The variable displacement piston type compressor is hereinafter referred to as a compressor. The cylinder block 11 is made of metallic material of aluminum series. The front end of the cylinder block 11 is joined to the rear end of the front housing 12. The rear end of the cylinder block 11 is joined to the front end of the rear housing 14 through a valve plate assembly 13. The cylinder block 11, the front housing 12 and the rear housing 14 form a compressor housing.

The cylinder block 11 and the front housing 12 define a crank chamber 15. A drive shaft 16 is supported for rotation by the compressor housing. The drive shaft 16 is made of metallic material of iron series and is connected to an engine for operation. The engine serves as a drive source for running a vehicle and is not shown in the drawing. The drive shaft 16 is rotated under power of the engine.

In the crank chamber 15, a lug plate 21 is fixed on the drive shaft 16 so as to integrally rotate with the drive shaft 16. Also, in the crank chamber 15, a swash plate 23 that serves as a cam is accommodated. A hinge mechanism 24 is interposed between the lug plate 21 and the swash plate 23. The swash plate 23 is connected to the lug plate 21 through the hinge mechanism 24 and is supported by the drive shaft 16. Therefore, the swash plate 23 is synchronously

rotated with the lug plate 21 and the drive shaft 16. At the same time, the swash plate 23 is inclined relative to a rotary axis of the drive shaft 16 while moving slidably along the direction of the rotary axis of the drive shaft 16.

A plurality of cylinder bores 11a is formed through the cylinder block 11 so as to surround the rear side of the drive shaft 16, although only one cylinder bore is illustrated in FIG. 1. A single-head piston 25 is accommodated for reciprocation in each cylinder bore 11a. The single-head piston 25 is hereinafter referred to as a piston 25. The front opening of each cylinder bore 11a is blocked by the associated piston 25 and the rear opening of each cylinder bore 11a is blocked by the valve plate assembly 13. In each cylinder bore 11a, a compression chamber 26, whose volume is varied in accordance with the reciprocation of the associated piston 25, is defined. Each piston 25 is engaged with the periphery of the swash plate 23 through a pair of shoes 27. Therefore, the rotation of the swash plate 23, which is accompanied by the rotation of the drive shaft 16, is converted to the reciprocation of the pistons 25 through the shoes 27.

In the rear housing 14, a suction chamber 28 and a discharge chamber 29 are defined. The suction chamber 28 is located substantially at the middle of the rear housing 14 while the discharge chamber 29 is located so as to surround the outer circumference of the suction chamber 28. The valve plate assembly 13 includes discharge ports 32 and discharge valves 33. Each discharge port 32

interconnects the associated compression chamber 26 with the discharge chamber 29. Each discharge valve 33, which is a reed valve, opens and closes the associated discharge port 32. In the cylinder block 11, a suction valve mechanism 35, which includes a rotary valve 41, is provided.

In a suction stroke, a refrigerant gas in the suction chamber 28 is drawn into each compression chamber 26 through the suction valve mechanism 35 while the associated piston 25 moves from the top dead center thereof to the bottom dead center thereof. In a discharge stroke, the refrigerant gas, which is drawn into the compression chamber 26, is compressed to a predetermined pressure value while the associated piston 25 moves from the bottom dead center thereof to the top dead center thereof, and the compressed refrigerant gas is discharged to the discharge chamber 29 through the discharge port 32 by pushing the associated discharge valve 33 aside.

Now, the structure of the suction valve mechanism 35 according to the preferred embodiment of the present invention will be described with reference to FIGs. 1 through 3.

As shown in FIGs. 1 and 2A, in the compressor housing, a valve accommodating chamber 42, which is surrounded by the cylinder bores 11a, is formed from the middle of the cylinder block 11 to the middle of the rear housing

14. The valve accommodating chamber 42, which has a cylindrical shape, communicates with the suction chamber 28 at the rear side thereof. A suction communicating passage 43, which is illustrated in FIG. 3, is formed in the cylinder block 11 for interconnecting the valve accommodating chamber 42 with the respective compression chamber 26 in the suction process.

In the valve accommodating chamber 42, the rotary valve 41 is accommodated for rotation. The rotary valve 41 has a cylindrical shape and openings to the suction chamber 28 and the crank chamber 15. An installation hole 41a is formed on the opening of the rotary valve 41 at the side of the crank chamber 15. The rotary valve 41 is made of metallic material of aluminum series. The rear end of the drive shaft 16 is placed in the valve accommodating chamber 42. A minor diametrical portion 16a is provided with the rear end of the drive shaft 16 and is fixedly press-fitted into the installation hole 41a of the rotary valve 41. Therefore, the rotary valve 41 and the drive shaft 16 are unified so as to serve as a single shaft and have a common rotary axis. That is, the rotary valve 41 is synchronously rotated with the rotation of the drive shaft 16, that is, the reciprocation of each piston 25.

Referring to FIG. 3, an introducing chamber 44 is formed in the rotary valve 41 so as to communicate with the suction chamber 28. That is, the suction chamber 28 and the introducing chamber 44 are equivalent to a suction pressure

region. As shown in FIG. 2A, a suction guiding hole 45 is formed in the outer circumferential surface 41b of the rotary valve 41 in a predetermined range of a rotational direction of the rotary valve 41. The suction guiding hole 45 has a substantially oval shape and has a major axis along the rotational direction. Referring back to FIG. 3, the suction guiding hole 45 extends from the outer circumferential surface 41b to the introducing chamber 44 and continuously communicates with the introducing chamber 44. That is, as shown in FIG. 2B, the suction guiding hole 45 has a predetermined area Sn per unit length ΔL in the rotational direction of the rotary valve 41. Note that the "n" denotes a natural number. The predetermined area Sn gradually increases from a first end surface 45a, which serves as a first end, formed at a preceding side in the rotational direction to a middle 45c of the oval shape. Also, the predetermined area Sn gradually decreases from the middle 45c to a second end surface 45b, which serves as a second end, formed at a following side in the rotational direction. The middle 45c is located between the first end surface 45a and the second end surface 45b. The suction guiding hole 45 and each suction communicating passage 43 form a refrigerant gas passage for interconnecting the introducing chamber 44 with at least the one compression chamber 26. As the rotary valve 41 is rotated, the suction guiding hole 45 connects each compression chamber 26 by turns with the suction pressure region.

That is, when the piston 25 is shifted to the suction stroke, the rotary

valve 41 is moved in a such manner that the first end surface 45a of the suction guiding hole 45, which precedes in the rotational direction of the rotary valve 41, opens the suction communicating passage 43 of the cylinder block 11. Therefore, the refrigerant gas in the suction chamber 28 is drawn into the compression chamber 26 through the introducing chamber 44 of the rotary valve 41, the suction guiding hole 45, and the suction communicating passage 43 of the cylinder block 11.

In the suction stroke of the piston 25, the suction guiding hole 45 continuously communicates with at least the one suction communicating passage 43. Meanwhile, as described above, since the suction guiding hole 45 is formed in the oval shape, an amount of the refrigerant gas, which is drawn into the compression chamber 26, continuously increases until the suction communicating passage 43 relatively reaches the middle 45c of the suction guiding hole 45 from the beginning of the suction stroke. That is, the amount of the refrigerant gas gradually increases. In contrast, after the suction communicating passage 43 relatively passes through the middle 45c of the suction guiding hole 45, the amount of the refrigerant gas, which is drawn into the compression chamber 26, continuously decreases. That is, the amount of the refrigerant gas gradually decreases.

On the contrary, at the end of the suction stroke of the piston 25, the

rotary valve 41 is moved in a such manner that the second end surface 45b of the suction guiding hole 45, which follows in the rotational direction of the rotary valve 41, closes the suction communicating passage 43 of the cylinder block 11. Thereby, the introduction of the refrigerant gas drawn into the compression chamber 26 is stopped. Subsequently, when the piston 25 is shifted to the discharge stroke, the suction communicating passage 43 is closed by the outer circumferential surface 41b of the rotary valve 41. Therefore, the refrigerant gas in the suction chamber 28 is not leaked through the suction communicating passage 43. Thereby, the compression of the refrigerant gas and the discharge of the refrigerant gas to the discharge chamber 29 are not prevented.

In the present embodiment, as shown in FIG. 3, at an early stage in the suction process, that is, while the predetermined area, by which the suction guiding hole 45 communicates with the suction communicating passage 43, gradually increases, the suction guiding hole 45 communicates with two compression chambers 26 (A, E). Also, at a last stage in the suction process, that is, while the predetermined area, by which the suction guiding hole 45 communicates with the suction communicating passage 43, gradually decreases, the suction guiding hole 45 communicates with two compression chambers 26 (A, E). Furthermore, during a slight time in the suction process, that is, at a stage other than the early and last stage in the suction process, the suction guiding hole 45 communicates with only one compression chamber 26. The suction guiding

hole 45 has an opening angle α in the rotational direction of the rotary valve 41. The opening angle α is set so as to fulfill the communicating state.

In the above-described embodiment, following effects are obtained.

(1) In the above-described structure, the suction guiding hole 45 has the predetermined area per unit length in the rotational direction. The predetermined area gradually increases from the first end surface 45a to the middle 45c, while gradually decreasing from the middle 45c to the second end surface 45b. Therefore, the amount of the refrigerant gas, which is drawn into the compression chamber 26 through the rotary valve 41, gradually increases from the first end surface 45a to the middle 45c. In contrast, the amount of the refrigerant gas gradually decreases from the middle 45c to the second end surface 45b. Furthermore, the opening angle α of the suction guiding hole 45 is set in a such manner that the suction guiding hole 45 communicates with two compression chambers at the early stage and the last stage in the suction process.

When the suction guiding hole 45 communicates with two suction communicating passages 43, that is, two compression chambers 26, as shown in FIG. 4B, each amount of gas that is drawn into the respective cylinder bore is added. Nevertheless, variation of the total amount of intake gas is restrained. That is, suction pulsation is restrained. Thereby, noise caused due to the suction

pulsation is reduced.

(2) In the above-described structure, the suction guiding hole 45 has the oval shape and has a major axis in the rotational direction of the rotary valve 41. Therefore, the suction guiding hole 45 is easily formed.

(3) In the above-described structure, the suction guiding hole 45 is formed in the oval shape, and has a major axis in the rotational direction of the rotary valve 41. The suction guiding hole 45 has a predetermined length in the direction of the rotary axis of the rotary valve 41. Therefore, the predetermined length near the first end surface 45a or the second end surface 45b is extremely smaller than the predetermined length at the middle 45c. Therefore, when the first end surface 45a communicates with the suction communicating passage 43, regardless of the time when refrigerant gas remaining in the compression chamber 26 finishes re-expansion, the amount of counter flow of the refrigerant gas is restrained. Thereby, power loss of the compressor is restrained. Furthermore, suction pulsation caused due to negative pressure in the compression chamber 26 is also restrained. Thereby, noise of the compressor is restrained.

In the present embodiment, the following alternative embodiments are also practiced.

In the above-described embodiment, the suction guiding hole 45 has the oval shape. In an alternative embodiment to the embodiment, however, the suction guiding hole 45 has, as shown in FIG. 5, a substantially rhombic shape. In this structure, similar effects to the above-described effects are also obtained.

In the above-described embodiment, the suction guiding hole 45 communicates with two compression chambers 26 at the early and last stages in the suction process. In an alternative embodiment to the embodiment, however, the opening angle of the suction guiding hole 45 is set in a such manner that the suction guiding hole 45 communicates with three compression chambers 26 at the early and last stages in the suction process. In this embodiment, similar effects (1) through (3) are also obtained. In addition, since two or more compression chambers 26 are in the suction process, the total amount of intake gas is increased. Thereby, cooling capacity of the compressor is increased.

In the above-described embodiment, the rotary valve 41 is made of metallic material of aluminum series. In alternative embodiments to the embodiment, however, the rotary valve 41 is made of metallic material of iron series or resin. Furthermore, the rotary valve 41 may be coated with resin.

In the above-described embodiment, the present invention is applied to a single-head piston type compressor. In an alternative embodiment to the

embodiment, however, the present invention is applied to a double-head piston type compressor.

In the above-described embodiment, the swash plate 23 is adopted as a cam. In an alternative embodiment to the embodiment, however, a wave cam is adopted as the cam and the present invention is applied to a piston type compressor, which is a wave cam type.

Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein but may be modified within the scope of the appended claims.